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Traffic information service: trials and developments 1975/76

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TRAFFIC INFORMATION SERVICE: TRIALS AND DEVELOPMENTS 1975/76

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Summary

The report forms a continuation of earlier work which established the need and feasibility of introducing a dedicated traffic information service, using a single medium frequency in time division multiplex, to serve the United Kingdom. A study of the effectiveness of a muting system in the receiver relying entirely on signal strength for restricting the coverage of each transmitter to local areas, revealed that variations of signal with vehicle movement gave spasmodic mute operation. This deficiency would have been particularly prevalent in fringe areas, causing only parts of messages to be heard, leading to possible confusion and ambiguity when interpreting the information.

A field trial was therefore set up to pursue the development of a system still based on the original concept, but which would overcome the problem of message fragmentation when motoring in an urban environment or leaving a service area. A description is given of the various listening modes offered by a prototype receiver, designed to respond to tone codes in transmissions. An analysis of results, based on the probability of communicating with a moving vehicle shows that the problem of message interruption due to local field-strength variations has been overcome.

This work represents an important stage in the development of the system and, although alternative muting arrangements have been developed since the work described was completed, the use of 'open' and 'close' codes has been retained as a valuable part of the system.

Issued under the authority of

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1. Introduction

In 1975 an initial study was made of the fundamental propagation problems that would dictate the transmission characteristics for a traffic information service. Consideration was also given to possible receiver designs for a system operating in time-division multiplex using a single medium frequency. The work concluded[1] that the original concept of a car receiver whose operation both before and during a transmitted message depended on a signal level detector[2] would be subject to certain shortcomings, particularly fragmentation of the message. Even at medium waves, small variations in field strength with vehicle movement meant that with a signal level selector, it would not always be possible to sustain an unmuted output for the duration of an announcement. Any spasmodic operation of the muting circuit is fundamentally alien to the philosophy of providing the motorist with complete, precise and non-ambiguous information. This report describes tests on the practical application of various ideas, and a discussion of the overall specification, for a dedicated traffic information network. It also adds to our previous understanding about the difficulties of communicating with a mobile audience and forms a significant step towards the development of a system which may be finally adopted for broadcasting both local and relevant traffic information to the motorist.

2. Methods of assessing the service

2.1. The field trial in outline

Before undertaking the engineering field trial, it was necessary to draw on knowledge already obtained and then proceed with the construction of sufficient hardware to demonstrate the reception reliability that could be achieved. Clearly, the minimum number of transmitters which can work in time-division multiplex (t.d.m.) is two. As this mode of operation seemed essential if the performance of a traffic receiver was to be thoroughly tested in a region of service area overlap, the field trial was based on two purpose-built transmitting stations: one for North London at Brookmans Park and the other to serve South London from Tatsfield. To ensure that each test station operated in sequence, programme origination and control equipment was installed at BBC Research Department, Kingswood Warren. By deciding on such an arrangement it was possible to fulfil three main requirements of the experiment:

(i) the ability to readily switch from a t.d.m. mode to a single transmitter radiating continuous wave, for propagation research and field strength survey;

(ii) provision for immediate alteration in message repetition rate, to cater for survey calibrations, system demonstrations, and the development of a prototype traffic information receiver;

(iii) to gain experience in message timing and remote transmitter carrier switching.

With reference to the object of (i), a measurement technique will be explained whereby it was possible to predict the effectiveness of the service to drivers in the rush hour.

Before proceeding with the survey work certain assumptions had to be made, mainly about the rates of vehicle flow in urban, suburban, and rural areas. Following a study of traffic statistics, a fairly valid comparison has been drawn between peak-period road travel and a model traffic situation, sufficiently representative to assess the quality of coverage for a moving audience.

After analysing some 2,000 route-kilometres of field-strength recordings, made with a whip aerial on a saloon car, it was possible to quantify the degree of message penetration for a substantial proportion of the test transmitter service areas in terms of 'communications efficiency' which is defined later. The basis for collecting field-strength data was to drive within a geographical matrix related to the National Grid and forming a block of 2·5 km x 2·5 km squares throughout the coverage target. However because it would have been too vast a project to visit every sample square, a way was devised of predicting the communications efficiency for those remaining unsurveyed. This idea has been introduced to cater for the very special problem of sending discrete messages to moving vehicles.

The relationship between distance, frequency and communications efficiency was also investigated by comparing reception performance in a number of squares selected to form 2·5 km-wide approximately radial strips from each transmitting site. In this work a comparison was made between frequencies at either end of the medium-frequency band or at v.h.f.

2.2. Characteristics of transmitted signal

A frequency of 593 kHz towards the lower end of the m.f. band was allocated for the experiment. The basic network requirement was that each test station should transmit on this frequency for a predetermined period following a command signal and then close down until the next command to radiate was given. By staggering the command signals and making the interval between them longer than the transmitter sending period, North London and South London transmitters were prevented from operating simultaneously. Thus interference between adjacent stations was avoided. To decide on a representative message-sending period for single incidents, a number of BBC Motoring Unit traffic announcements were assessed for duration. The average announcement time was 16 seconds, so an active message period of around 20 seconds would seem to cover most eventualities and was chosen as a suitable trial value.

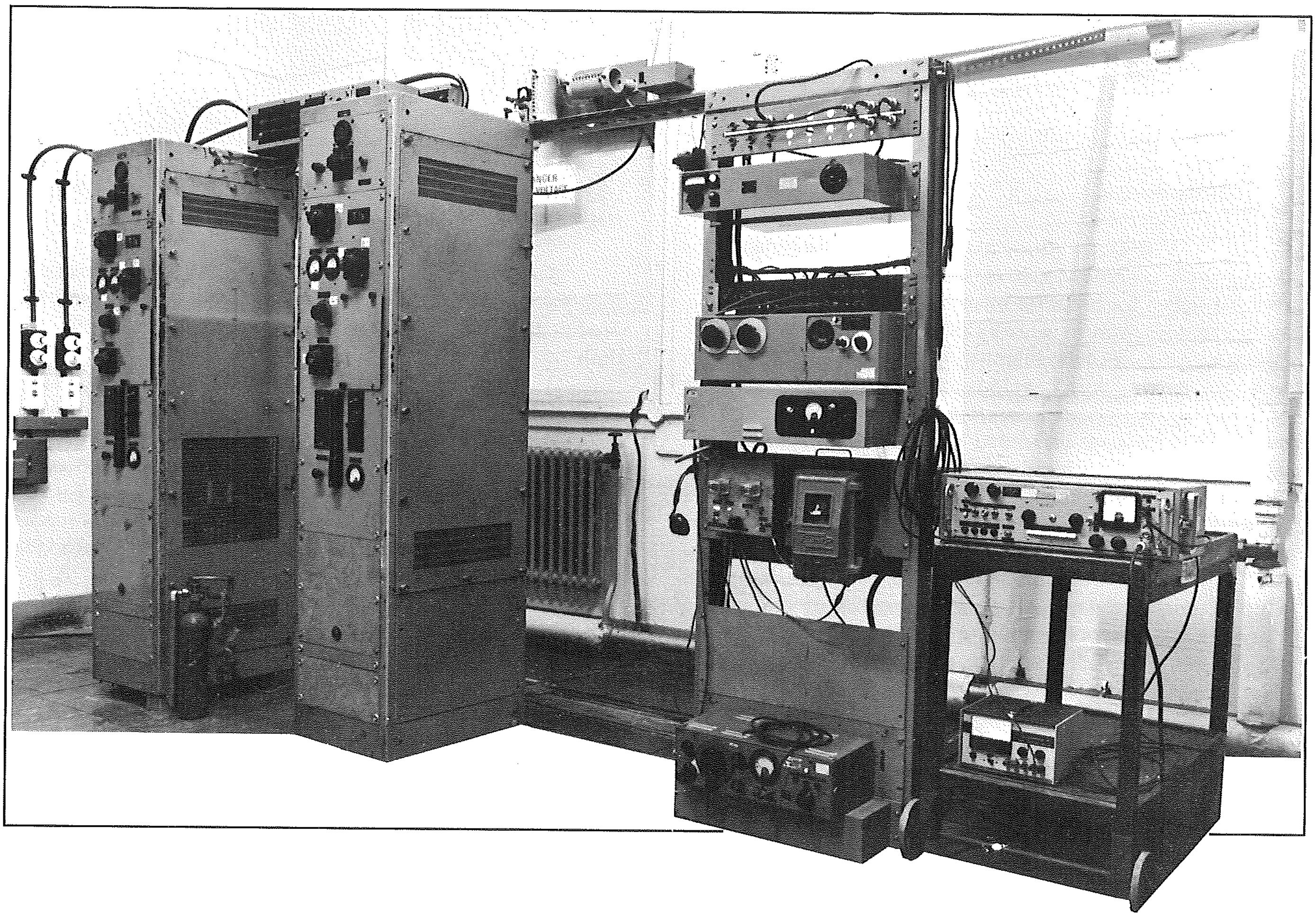

Fig. 1 - Tatsfield transmitting station

The undesirable effect of spasmodic receiver mute operation cannot be over emphasized, particularly when driving near a limit of coverage. For example, a listener hearing the partial message '...... police ask that drivers take their advice at least for the next hour, and remember this involves Oxford Street, Regent Street and part of Piccadilly' would not know whether to totally avoid the area or use the route as a detour. Therefore, on the assumption that a complete announcement should be either heard or missed, so that it cannot be misconstrued, it was necessary to transmit additional switching information so that the experimental receiver could be designed to work on this 'all or nothing' basis. By transmitting two electronically different tone modulations, one just before the spoken message and the other immediately afterwards, a decoder in the receiver could be used to prevent operation of the signal-level muting circuit during the announcement. This meant that in the period between these 'opening' and 'closing' codes, any reduction in local field strength merely caused a deterioration in signal-to-noise ratio as the receiver a.g.c. endeavoured to maintain a constant audio output level. In other words, the traffic receiver performed as an ordinary car radio for the duration of the message. If for any reason the closing code was missed, perhaps while passing under a bridge, a timer re-set the signal level detector after a fixed period of about 40 seconds following the reception of the opening code.

A further feature that led to improved message acquisition was the radiation for six seconds of a plain radio frequency carrier before the opening code. With the aid of a peak detector with a fast charge and slow discharge, the selector had only to be driven momentarily above its threshold to produce an unmuted feed to the decoder. Apart from automatically identifying the local traffic station, the relatively long sampling period was especially beneficial in areas of excessive local field-strength variation. Generally, it was when amongst high buildings that the six seconds for a signal acceptance decision was most effective and so gave more consistent urban reception when just within the limit of service. The duration of the sampling period is somewhat arbitrary, but an early study of field-strength variation when driving in marginally served urban areas revealed that relative to say, half a second, six seconds increased the probability of message acquisition by one and a half times. To extend the time would reduce the usable information period and tend to give little further improvement.

2.3. The medium-wave transmitters

A photograph of the Tatsfield installation is shown in Fig. 1. Working from right to left, the signal chain commences with the link receiver feeding the demodulated u.h.f. from Kingswood to the programme input equipment

mounted on the apparatus bay. In addition to a modulation-level limiter and peak programme meter it contains the remotely controlled carrier-switching unit and a tone source for line-up purposes. Above the jack field towards the top of the bay can be seen the r.f. crystal drive amplifier and distribution panel. Finally there stands the 2 x 250 watt RCA transmitters, type ET-4336, surmounted by the r.f. output combining unit. To the rear and fixed to the wall, is the aerial matching circuit with suitable values to transform an equivalent transmitter output impedance of 60Ω to that of a 'T' aerial. The transmitters gave about 8 amps into the base of the down lead; from the known power this implies a series earth and radiation resistance of approximately 8Ω. The station had a near omni-directional radiation pattern with a maximum e.m.r.p. of 225 watts. By using similar transmitters at Brookmans Park, but housed in a caravan, and a more efficient aerial, an e.m.r.p. of 300 watts was radiated towards London.

At the start of the control and modulation chain, a twin-track, self-reversing cassette machine was used to replay a 30 minute tape. Thus, it was possible to maintain a continuous programme output, without having to resort to short tape-loops with the associated problems of tape wear and long-term reliability. Fig. 2 is a photograph of this equipment showing the player on the left of the bottom panel with the audio distribution amplifiers and tone sources positioned above.

Further details of the transmitter control is given in Section 10.1 of the Appendix. The essential functions of the apparatus, installed at Kingswood Warren, were to control the switching on and off of the transmitters (using 6 kHz signals not radiated) and to give sample messages preceded and followed by 'open' and 'close' audio codes. The codes used for the trial were as follows:

Open: 2325 Hz signal, with 115 Hz square-wave f.m. at a deviation of ±175 Hz. Duration 1 second.

Close: 2325 Hz signal, with 115 Hz square-wave f.m. at a deviation of ±75 Hz. Duration 0·5 second.

These modulations drove the receiver decoder which comprised an f.m. discriminator, followed by an a.f. detector feeding a Schmitt trigger having two amplitude thresholds; this in turn acted upon a bistable circuit with two states that either corresponded to the signal-level-dependent condition or the listening mode. A description of a demonstration receiving equipment is given in the Appendix, Section 10.2.

3. A survey to derive communications efficiency

3.1. The communications efficiency concept

We wish to determine the percentage of total motorists travelling at peak periods, that would be able to receive a traffic announcement from a particular transmitter. The measured or predicted result derived for each small test area is termed the communciations efficiency (c.e.). Providing it could be arranged for the survey car to reconstruct a valid model of a typical day-to-day traffic situation

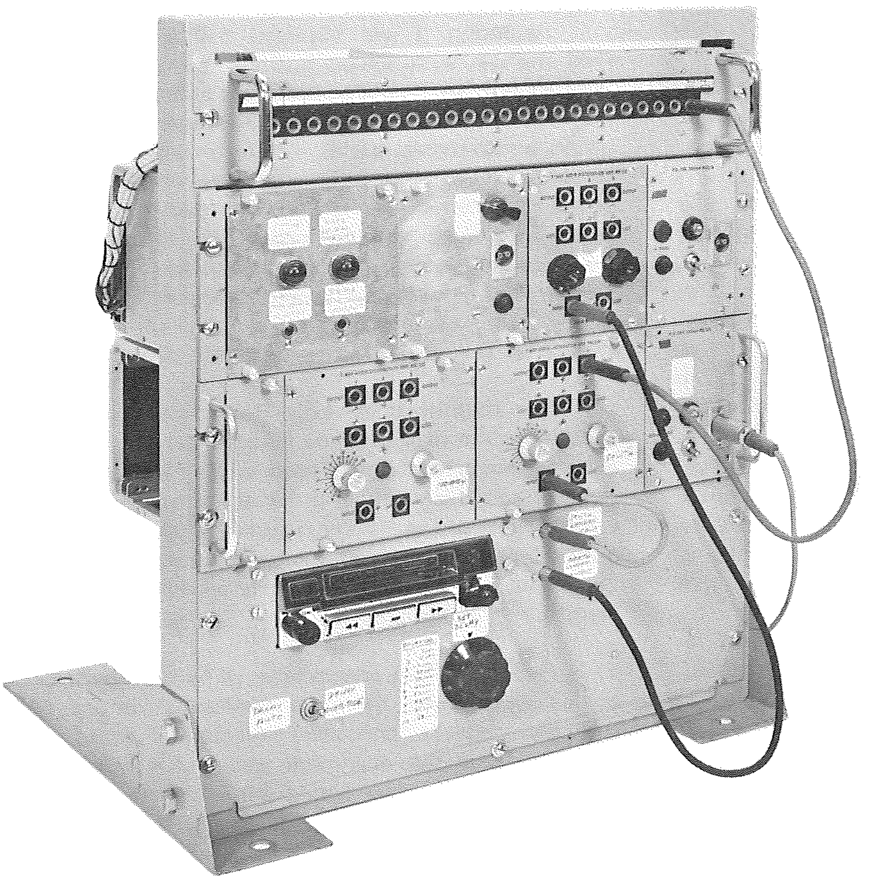

Fig. 2 - Transmitter control and modulation equipment

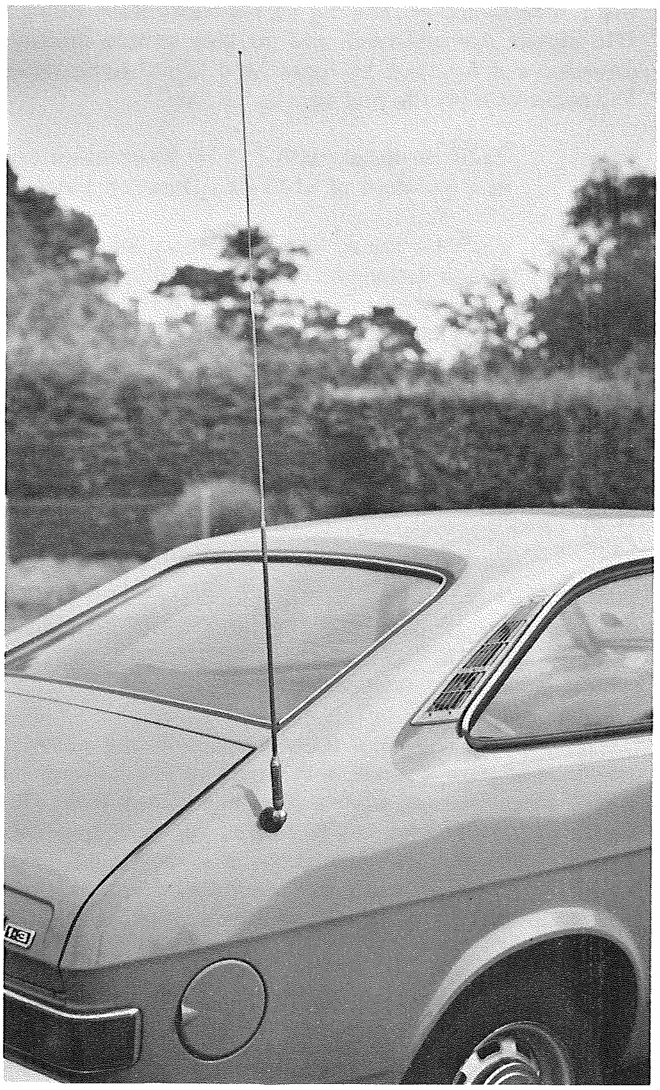

Fig. 3 - Survey car aerial siting

throughout the measurements, then the c.e. would also indicate the percentage of total announcements transmitted that would be available to each motorist.

It is traditional to show coverage at medium frequencies by drawing field-strength contours on a map. In the first instance, it was uncertain that a contour of 3 mV/m would depict a representative limit of service for a traffic receiver with the mute threshold set to the same value. Hence, the first requirement was to make a practical assessment of the difference between field-strength measurements made on an open site, and the median values available to the motorist when driving in the urban, suburban or rural areas surrounding the same open site.

A Morris Marina was therefore equipped with a typical telescopic car aerial, 1·2 m long when fully extended. The aerial was mounted on the off-side rear and Fig. 3 shows it to be relatively clear of the saloon, so ensuring best efficiency. Moreover, it was convenient to place the field-strength measuring receiver on the rear seat and so a further signal-input advantage resulted from using a short feeder to give minimum shunt capacitance across the aperiodic aerial-input circuit (2500Ω in parallel with 2pF). The receiver was tuned to 593 kHz and the external-meter socket fed to a pen recorder.

An overall field-strength calibration for the aerial and measuring equipment was readily obtained by placing the entire car in a field of known intensity on an open site. In general, it was possible to achieve two calibration levels when the transmitters were in t.d.m. by noting the field of Brookmans Park and Tatsfield in turn. This procedure gave a check on the linearity of the receiver input/output law. By radiating c.w. from Tatsfield only, and first plotting the 3 mV/m contour in the conventional way at a number of clutter-free locations between Leatherhead, Epsom and Kingston, it was possible to define a strip of interest, about 5 km either side of the contour. To determine the extent of the problem, roads within the strip were surveyed using the Marina equipment and the instantaneous level of field strength noted at an arbitrary interval of every two minutes. A detailed presentation of the results of this early work is unnecessary, but two important factors emerged that were to influence the way coverage data for a traffic information service were to be prepared.

Firstly, when driving in a dense urban centre, levels of field strength could be as much as 10 dB below the nominal 3 mV/m for the strip, due to the proximity of large steel-frame buildings, etc. Even in brick-built suburbs, depressions of 3 dB to 4 dB were not uncommon. On the other hand, recordings made on rural roads were in close agreement with the nominal field and sometimes when travelling along roads with crash barriers or near overhead power lines, the field could be enhanced.

Secondly, it was observed that local variations of field strength with vehicle position, throughout a distance as short as 1 km, would be sufficient to cause certain traffic receivers to unmute on receipt of an announcement, while others would remain silent. Clearly a method of specifying an information coverage area in terms which take account of the motorists speed, location and road occupancy would be an advantage. Furthermore, if the effect of a driver's ever-changing surroundings could also be included, then a far more definitive picture would emerge.

3.2. The simulation of a peak traffic period

The assessment of a live traffic situation, in which rush-hour motorists could be asked if they had received an announcement from one or more of their local transmitters, requires a suitable number of locations for the single survey vehicle to examine. To reduce the problem to one of managable proportions, the sampling process was split into two levels, one at unit-area density and the other at driver density.

A map with the service areas of both Brookmans Park and Tatsfield was therefore overlayed with a matrix and each square contained therein allocated a c.e. Assuming that the maximum range of a single traffic-information transmitter would seldom exceed 45 km, the total area of interest amounts to some 6250 sq. km. The preliminary work suggested that by making each square

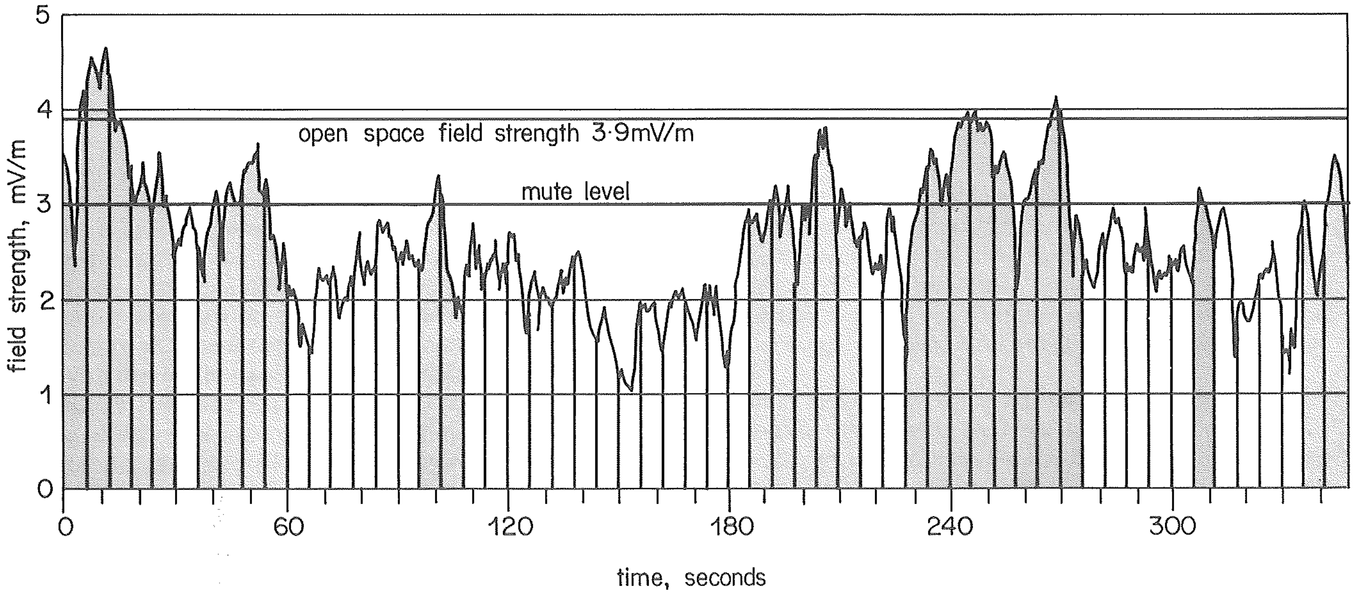

Fig. 4 - Brookmans Park Chart recording: strip B, square 49 on Fig. 5

No. of samples = 58 c.e. = 47% for 3 mV/m mute

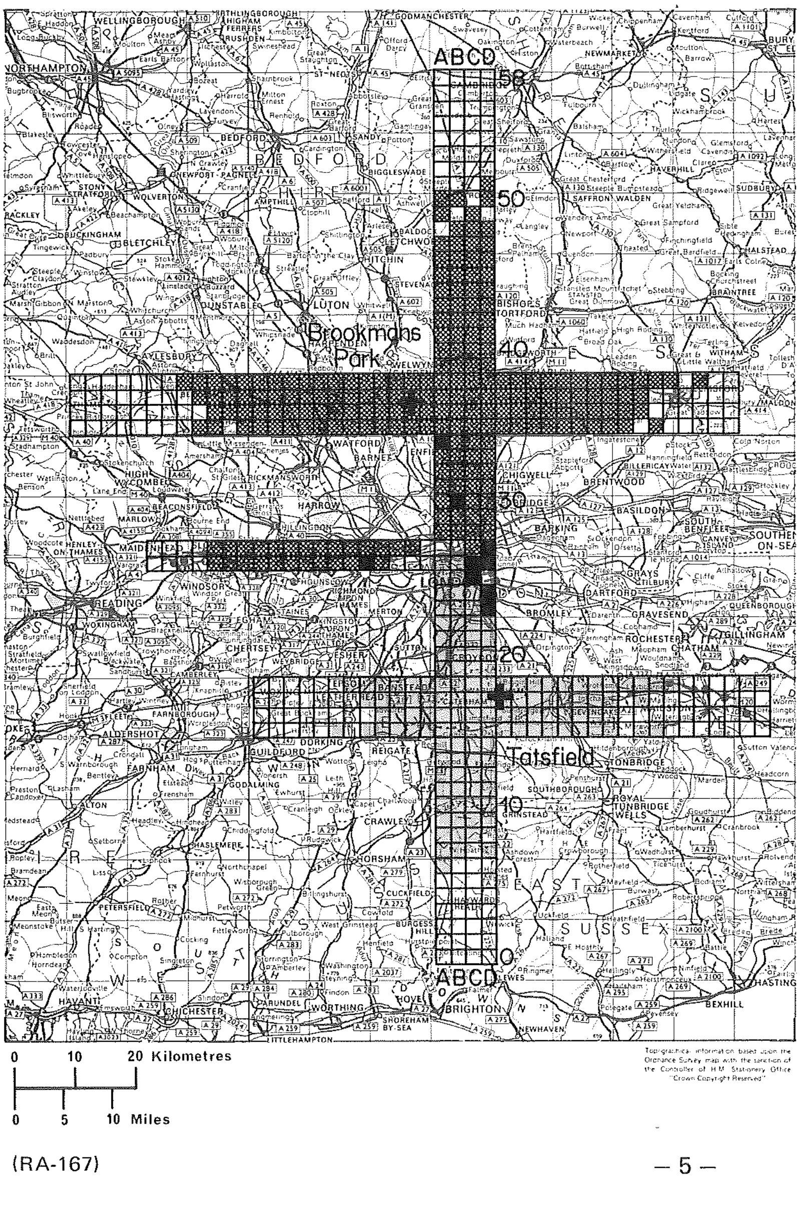

Fig. 5 - Survey squares location map showing communications efficiency ⩾ 50% for 3 mV/m

- Brookmans Park ⩾ 50%
- Tatsfield ⩾ 50%
- Brookmans Park and Tatsfield ⩾ 50%

2·5 km x 2·5 km, the type of building clutter would be sufficiently representative within it, while at the same time, give enough road mileage to permit ease of survey route selection. With regard to the total distance surveyed in each square, it was desirable to sample locations occupied by drivers travelling mainly on motorways and A-class roads, but include the occasional B-class road in rural areas. After studying the relevant 1:50,000 series Ordnance Survey maps, it was concluded that 5 km per square would provide a reasonable compromise. An area of 6·25 sq. km per square meant that the results from about 1,000 squares could go towards forming the final coverage assessment.

As mentioned earlier, the experimental traffic receiver was designed to monitor the field strength for a six-second period immediately before each announcement. Should a mute level of 3 mV/m be exceeded for any instant during this time, the driver was deemed to be within receiving range, and the message decoded. In view of the proposed transmission system, the paper chart roll was driven by a clock rather than the road wheels, because it seemed more appropriate that any study of driver information and the number of announcements heard, be related to the time taken to complete the journey, including hold-ups, rather than the total distance travelled. Thus, by a process of pen recording a continuous series of six-second intervals while motoring along each 5 km route, it was possible to make level tests which were typical of the true field strength/time pattern, rather than the distribution of field strength with location.

4. The measurement survey

4.1. Description of measurement method

The example of chart recording in Fig. 4 shows the field strength measured from a continuous transmission while covering a 5 km route within a 2·5 km x 2·5 km rural square that included the village of Therfield, 4 km South-West of Royston. Every six seconds a short-circuit was momentarily placed across the input to the pen drive amplifier. Thus it was possible to automatically reproduce the action of the traffic receiver pre-message sampling period, ready for peak-level analysis. To determine the communications efficiency of a particular value of mute, the number of samples which exceeded the prescribed level for any instant was divided by the total number of samples in the square and converted to percentage. During the six-second periods shown shaded on the chart, the 3 mV/m mute level was exceeded on 27 separate occasions and with a total of 58 samples; this gives a c.e. of 47%. Wherever practicable before leaving a square, the portable field strength meter was removed from the car and switched to the internal loop aerial, to make an open-space measurement clear of electrical obstructions, consistent with the long established technique. For the square in question, an open-space value of 3·9 mV/m

Note. E.M.R.P. of Brookmans Park varies from 200W in the north to 300W in the south

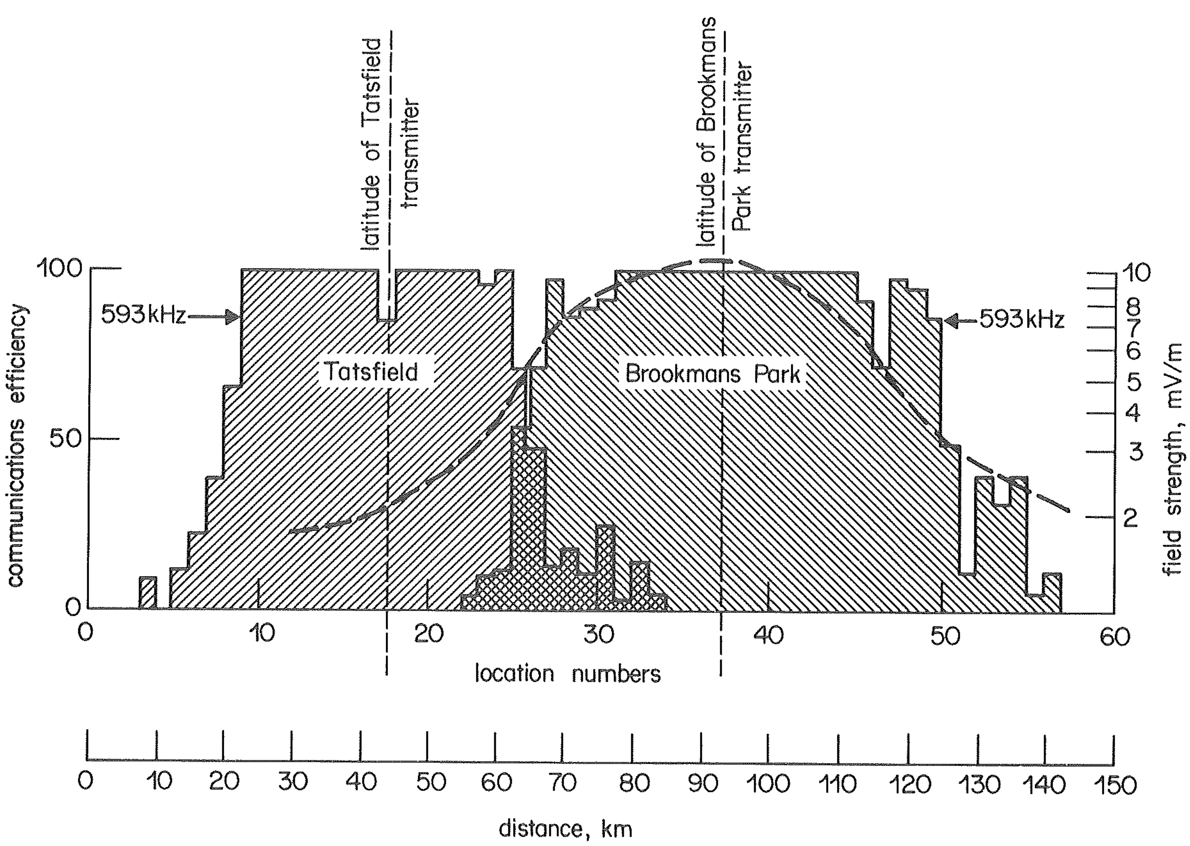

Fig. 6 - Communications efficiency/sample locations: strip C, for 3 mV/m mute

c.e. — 'open space' field strength

was recorded. This was taken as corresponding to the measured value for uncluttered sites, applicable to the entire square.

4.2. Application of measurement method

It was apparent from the outset that the cost effectiveness of visiting every square associated with the Brookmans Park and Tatsfield coverage was open to question. A partial survey was therefore initiated, and used in conjunction with a prediction process to be described in Section 5. Once enough data had been acquired to confidently extrapolate estimates outside the measurement area, and also to make a performance comparison between two m.f. channels and a v.h.f. channel, the survey was terminated. The extent of the individual 5 km route survey is given by the partial matrix in Fig. 5 and a result was produced for each 2·5 km x 2·5 km square contained therein. Every square for which the c.e. was 50% or more, has been shaded and maximum density applied where a qualifying contribution was received from both Brookmans Park and Tatsfield.

Another way of presenting the measured values of c.e. and at the same time giving an impression of the interface between two adjacent stations, is to plot communications efficiency against the location of sample squares. For identification purposes, the central four-square-wide block, running from Brighton to Cambridge on the map, has been labelled with Eastings A to D and Northings 0 to 58. From Fig. 6 it can be seen how transmitter e.m.r.p. can be engineered to give the required local traffic-programme content with an abrupt changeover from Tatsfield to Brookmans Park around the 50% level along strip C. An indication of how a receiver mute makes for compact coverage areas and provides a high effective cut-off rate at the service periphery, is demonstrated by a comparison with the open-space field values for Brookmans Park, which fall less rapidly since the station would provide a conventional service to a greater range.

4.3. The effect of frequency: m.f. and v.h.f.

By showing two additional strips, A and B, it is possible to display the performance consistency on 593 kHz within strips A, B and C forming a band 7·5 km wide. For comparison with these results for Brookmans Park, c.e. values for 1457 kHz from the same site (BBC Radio London) and for v.h.f. on 95·8 MHz (ILR service) from Croydon can also be displayed. In both cases the result is much as expected with Fig. 7 showing 1457 kHz to suffer a higher rate of ground wave attenuation than 593 kHz. The v.h.f. plot in Fig. 8 not only shows a reduced range, but exhibits a more variable distribution of communications efficiency relative to location number, so indicating that v.h.f. propagation would conflict with the requirement of local and unbroken coverage. For example, values of up to 75% emerge as islands of high efficiency in an elevated, clutter free rural district and these are placed well outside the primary limit

However, the distance over which there is a change from good service to virtual cut-off should be considered as

Note. The E.M.R.P. of Radio London was adjusted during analysis to equal the 593 kHz E.M.R.P.

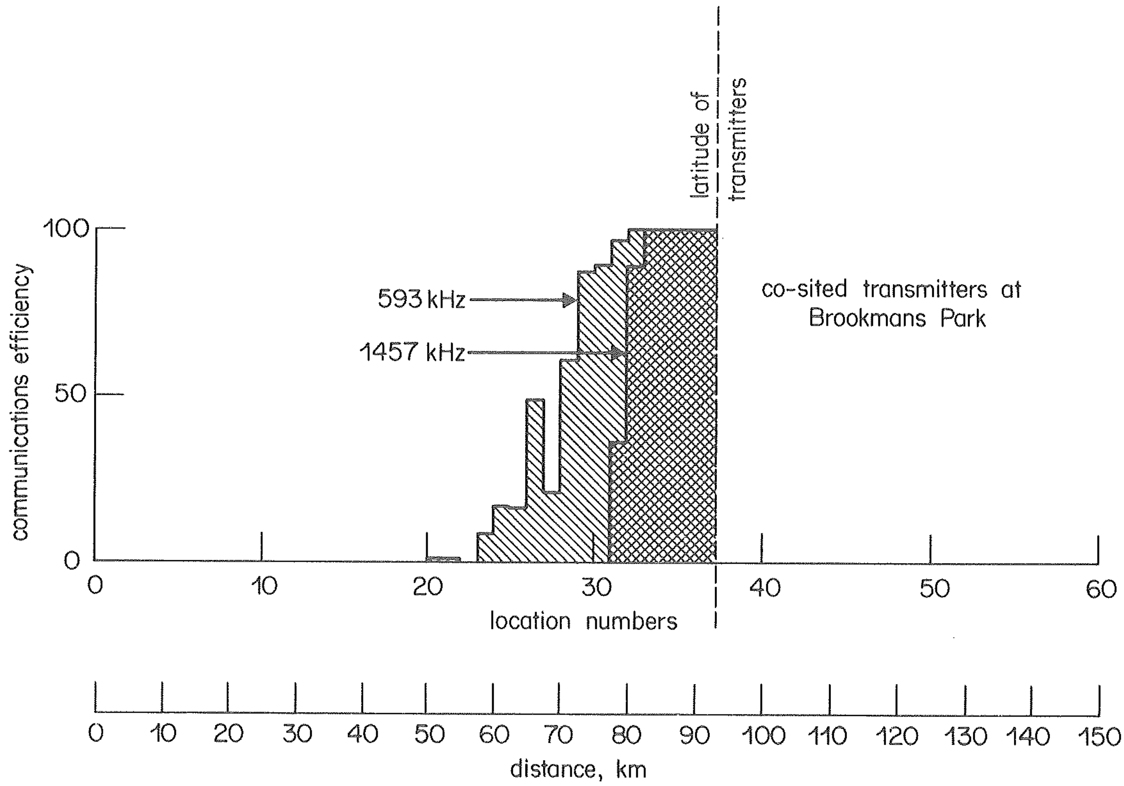

Fig. 7 - Communications efficiency/sample locations: strip A, for 3 mV/m mute

Note. The E.R.P. of Croydon was adjusted during analysis to equal the Brookmans Park 593kHz E.M.R.P.

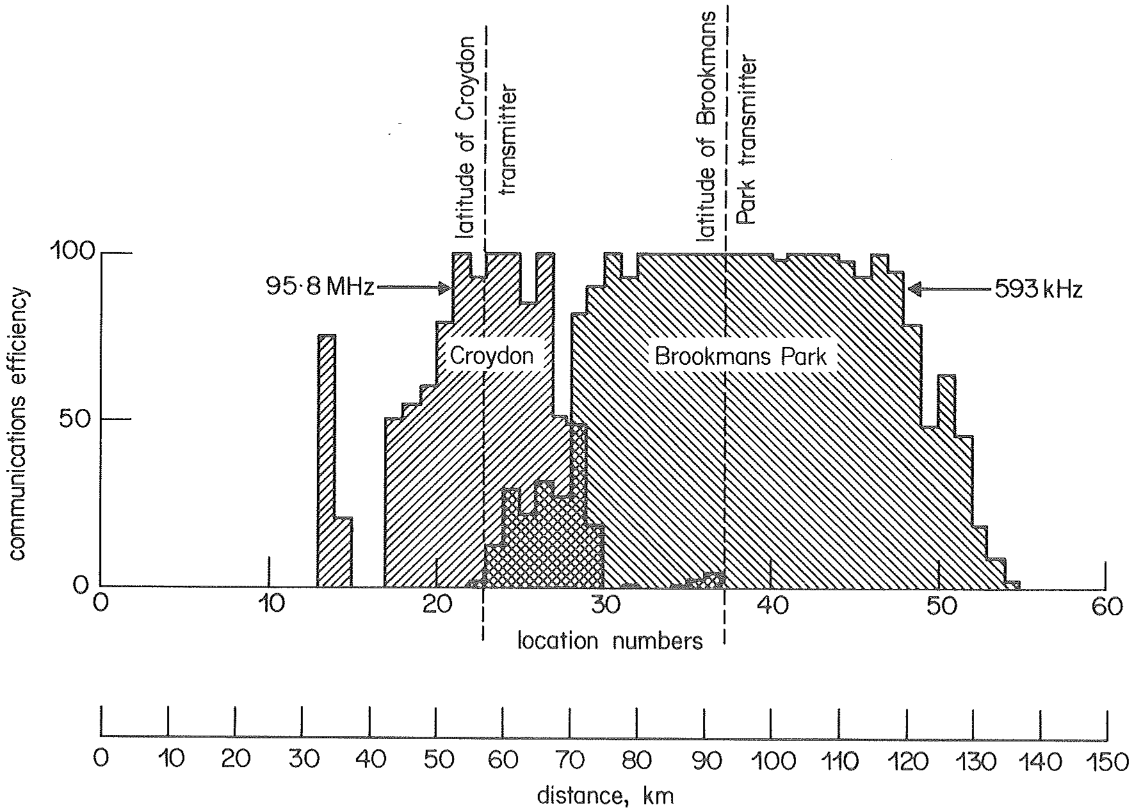

Fig. 8 - Communications efficiency/sample locations: strip B, for 3 mV/m mute

a fraction of the effective range, say out to a c.e. of 50%. On this basis the difference between the two m.f. results is not so marked, but v.h.f. is considerably poorer.

5. The prediction method

5.1. General

To avoid the need to survey every relevant square around each transmitter site under consideration, the measured data was used to derive a prediction method for the c.e. It then became possible to complete the maps for Brookmans Park and Tatsfield by showing contours enclosing areas within which the 50%, 70% and 90% values are exceeded. The process was then extended to prepare coverage information for a preliminary twelve station network to serve SE England, the West Country and the Midlands. This formed the basis for discussion and assessment of how any future proposal for a traffic information service to the public might evolve.

5.2. Preparation of the basic data

The first requirement was to obtain a map of suitable scale, say 1:250,000, surrounding the chosen transmitter site. Field strength contours in 1 mV/m intervals, from 3 mV/m to 10 mV/m inclusive were then drawn for the appropriate e.m.r.p. generally between 150 watts and 300 watts, depending on aerial efficiency. The contour value represents the average level expected in an open space environment and can either be measured using test transmissions, or if to be co-sited with a previously measured m.f. station, existing results for some other power and frequency used as a guide to site performance. In the latter case, or where a new broadcasting site has been selected, application of the ground wave propagation curves[3] can provide all necessary field strength/distance information.

The next stage was to take the Ordnance Survey national grid system as a reference and identify a 2·5 km x 2·5 km matrix by drawing squares on the map to just beyond the 3 mV/m contour. There then followed a process of building density classification, whereby each square was assessed from the map and designated either rural, suburban or urban with the respective notations, R S and U. Two transitional categories were also introduced, namely rural/suburban (RS) and suburban/urban (SU) to help decision making and provide greater scope for interpolation. Sometimes a larger scale map, e.g. 1:50,000, was consulted and in extreme cases a visit to obtain first hand knowledge about the distribution of local development, would dispel any remaining doubt. Fig. 9 illustrates the process so far described and shows the NW quadrant of the Brookmans Park service area prediction.

5.3. Relationship between field strength and communications efficiency

To establish an empirical relationship between the field-strength contours and communications efficiency was

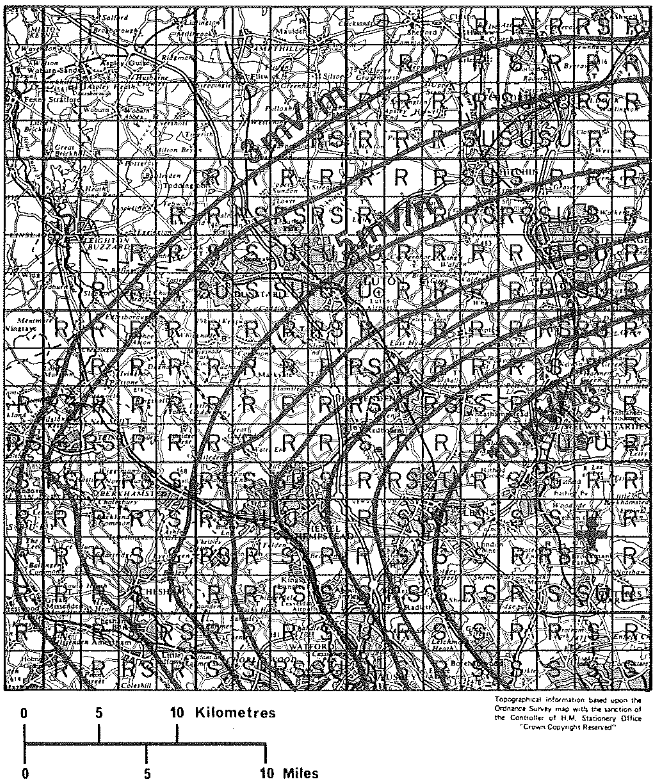

Fig. 9 - Predicted field strength contours and clutter categories for north west of Brookmans Park

merely a question of examining a relevant selection of the 554 Brookmans Park and Tatsfield squares surveyed. By separating the areas for which measurement data were available into the three building density classifications and plotting open-space values in mV/m against each corresponding c.e. analysis, the set of conversion curves shown in Fig. 10 were produced. For a mute level of 3 mV/m, the curves show that the useful range of field strength from which a usable contribution could be obtained, was limited to between 2·3 mV/m and 11·4 mV/m, – a spread that embraces all categories of communication efficiency from 0% Rural to 100% Urban. By passing the information contained in Fig. 9 through the conversion process afforded by Fig. 10 each square was allocated a value of communications efficiency and the numerical matrix shown in Fig. 11 could be produced. The final operation was to establish three boundary lines around squares where the c.e. was greater than certain helpful planning parameters, namely 50%, 70% and 90%.

Fig. 12 is a completed picture showing how the prediction method was used to complement the limited measurement programme for the two test transmitters. The map gives a result in terms of message penetration or vehicle coverage for the entire Brookmans Park and Tatsfield service areas.

6. Clutter loss compensation in urban areas

6.1. Service area considerations

The discussion has so far been based on a traffic

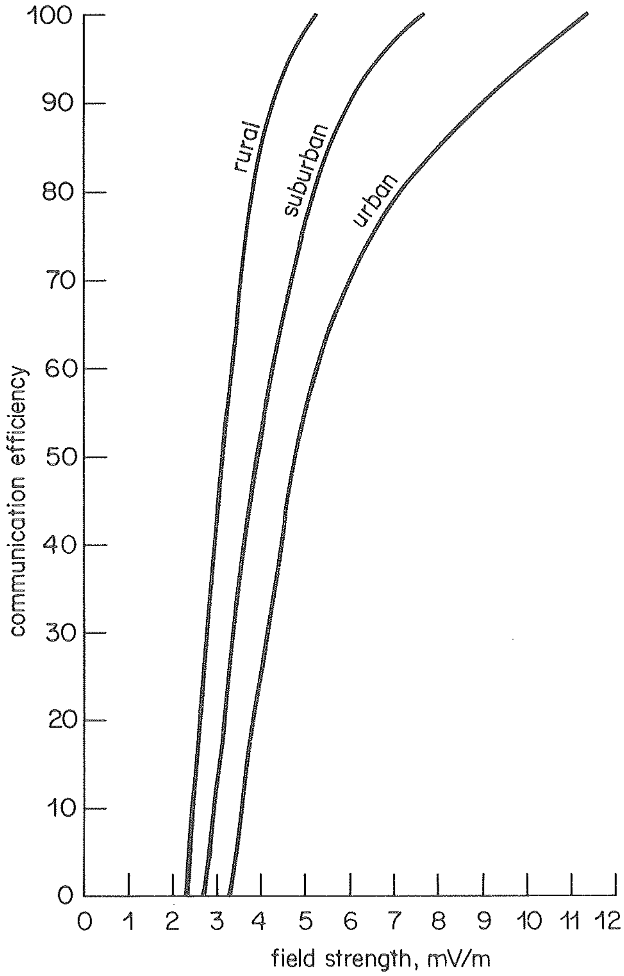

Fig. 10 - Relationship between communications efficiency and open-space field strength for traffic receivers with 3 mV/m mute

receiver having a mute threshold of 3 mV/m. To illustrate certain undesirable aspects of the service areas so obtained, let us consider a motorist travelling through a rural area, say with an open space field strength of 4·3 mV/m. According to Fig. 13 the c.e. would then be around 90% and in all probability a reliable information channel established. The motorist in question now enters an urban area subject to a similar open space field but the performance of a receiver containing a 3 mV/m mute is shown to drop substantially and a c.e. worse than 50% immediately results. However, it can be seen that if the mute setting is changed to 1 mV/m, then the c.e. is at once restored to better than 90%. By applying this result to the urban areas in Fig. 12 and saying that as a rough guide the 50% contour becomes the 90% contour, then the coverage in towns appears to be far more homogenous, with places like Luton, Watford and Tunbridge Wells becoming well served. For low m.f. (500 kHz – 550 kHz), it is generally accepted that a reasonable signal-to-noise ratio can only be obtained when the median field strength exceeds 2 mV/m. Even so, for short speech transmissions using compression, fields down to 1 mV/m can still be regarded as more than acceptable providing the car is fitted with an external whip aerial at least 1 m long.

On the other hand, it has already been shown[1] that to

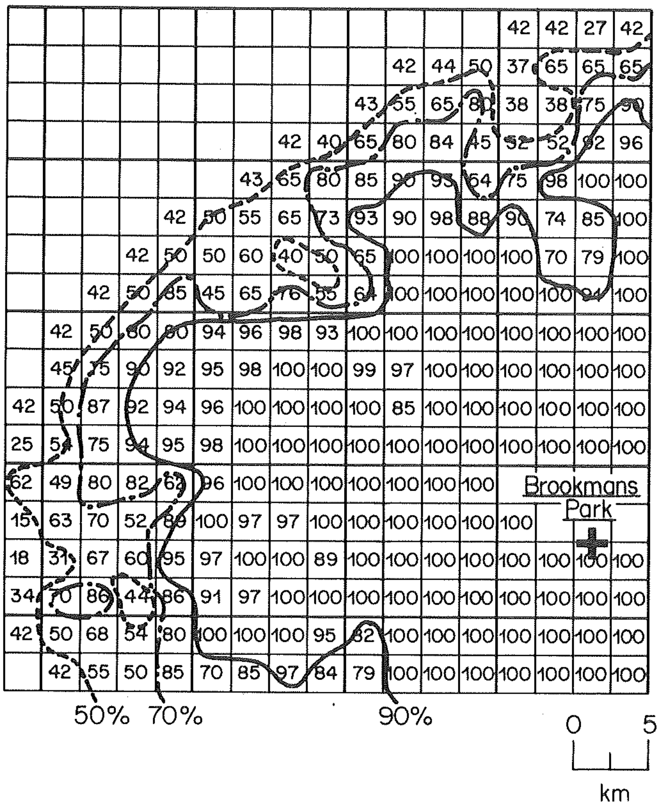

Fig. 11 - Communications efficiency matrix and contours for 3 mV/m mute north west of Brookmans Park

obtain a protection ratio of 18 dB against the interfering effects of ground wave propagation from simultaneously operated transmitters, the wanted field must be as high as 2·5 mV/m (68 dB(μV/m)), increasing to 3·5 mV/m (71 dB (μV/m)) to avoid the undesirable skywave effect of a basic 16 station t.d.m. lattice. Of course the final performance would depend very much on the frequency allocated but in urban areas it is reasonable to suggest that clutter attenuation, albeit somewhat reduced compared with that of the wanted signal at night, would also apply to the interference. Moreover, it is possible that the protection ratio could be further restored due to the vertical radiation pattern (v.r.p.) of the whip aerial as the majority of significant skywave sources would arrive at an angle of around 45° above the horizontal. A few simple receiving aerial measurements have indicated that this would introduce a beneficial reduction of interference by some 2 dB to 3 dB. However, as it is intended that drivers should obtain advance information at home using a domestic version of the traffic receiver, it would be wrong to include a general v.r.p. allowance when calculating the usable field strength during skywave propagation, because the type of battery portable in mind would invariably be fitted with a ferrite-rod aerial.

6.2. Local considerations

A case has been made in 6.1 for the traffic receiver design to include a choice of mute threshold. The selection could either be made by the driver operating a two-position switch labelled 'Town/Country' to give muting at 1 mV/m and 3 mV/m respectively, or by employing an

Fig. 12 - Communications efficiency service area prediction for 3 mV/m mute of Brookmans Park and Tatsfield

>90%

90%-70%

70%-50%

<50%

0 10 20 kilometres

0 5 10 miles

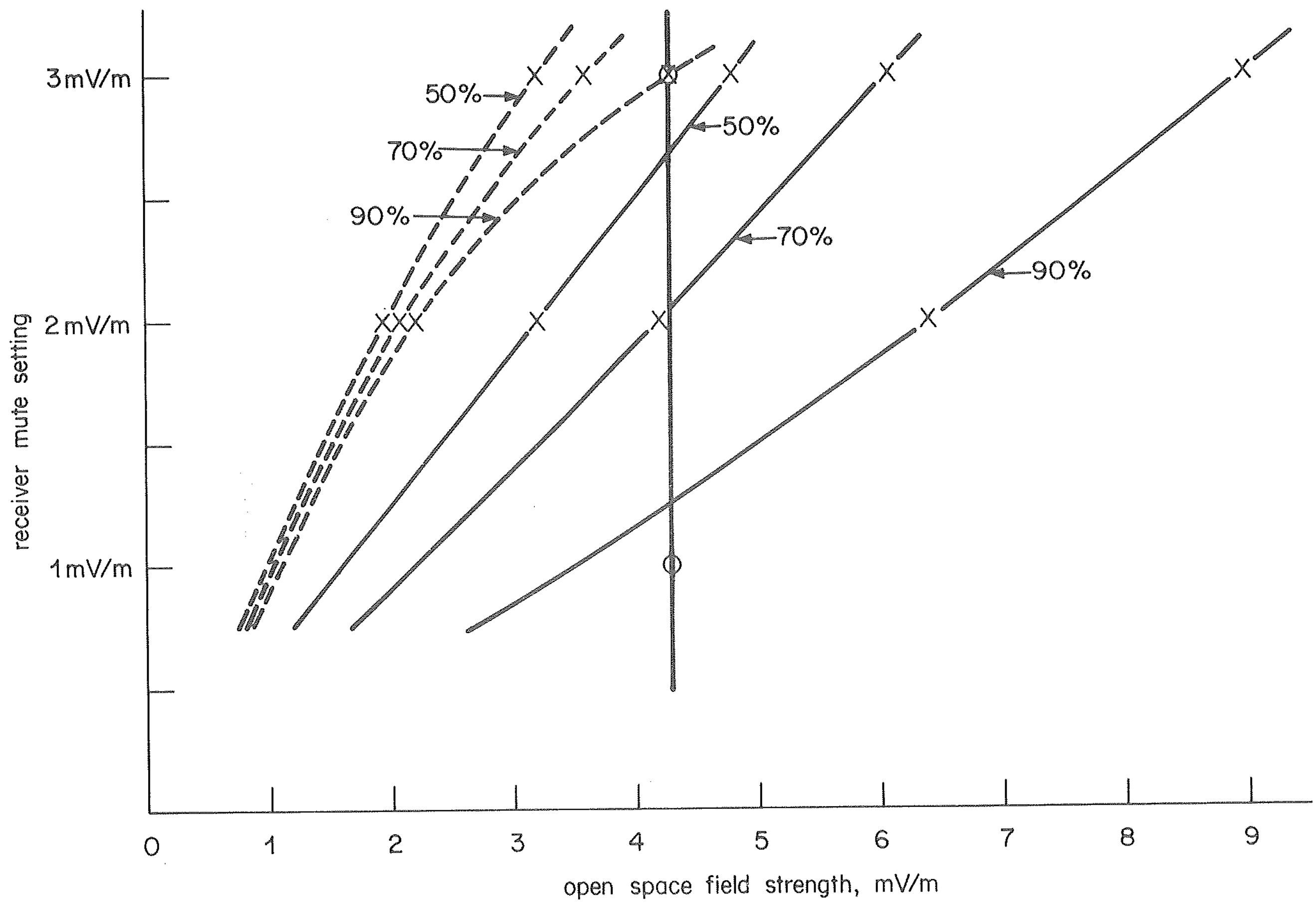

Fig. 13 - Communications efficiency as a function of open space field strength and mute setting

— — — rural ——— urban

electronically adaptive system, which would in some way, memorize the level trends of the previous two or three messages. Consideration is now given to some further and more detailed results depicting the advantage of lower mute settings when the received signal is influenced by the effect of local steel frame buildings, etc. A block of 16 squares, each measuring 2·5 km x 2·5 km and centred on the high urban density of Southwark/Lewisham, has been extracted from the Brookmans Park survey and the communications efficiency of each square analysed for three values of mute. The results in Fig. 14 are for thresholds of 3 mV/m, 2 mV/m, 1 mV/m and clearly indicate that when set to the lowest value, more than 95% of announcements would be decoded, regardless of location along the road. Using a 3 mV/m mute, reception becomes far more variable with efficiencies ranging from 8% to 97%. By including results for 2 mV/m level, it can be seen how the muting level is still insufficiently low to latch on to a reliable number of announcements when transmissions have been subjected to attenuating obstacles typical of most town centres.

7. Conclusions

The report forms an extension to the fundamental concept of relying on the field strength/distance decay to limit the service area of a medium frequency transmitter. Message acquisition was improved by radiating a plain carrier for a period of six seconds before each start code. Thus, by employing a peak detector to drive the mute so smoothing out any signal variation with vehicle movement, receiver operation became more decisive during transmitter sampling periods, giving more clearly defined limits of service. The work also verified the advantage of introducing opening and closing codes to sustain the message for its entire duration, thereby avoiding transmission of partial information.

Due to the difficulty of applying traditional field strength criteria when dealing with the statistical problem of vehicles moving through differing degrees of urban clutter, a method of assessing the amount of information conveyed was developed. The term 'communications efficiency' has been used to express the probability of reception and is more readily related to the overall system performance than a map showing areas bounded by field strength contours. The idea was particularly well regarded among Police Officers and Traffic Engineers.

The comparison between high m.f., low m.f. and v.h.f. showed that v.h.f. would be at a severe disadvantage and it would be preferable to aim at as low a frequency as possible in the medium frequency band to obtain best urban penetration for a given e.m.r.p. It also provides the nearest approximation to a desired non-fluctuating attenuation characteristic associated with an inverse distance law.

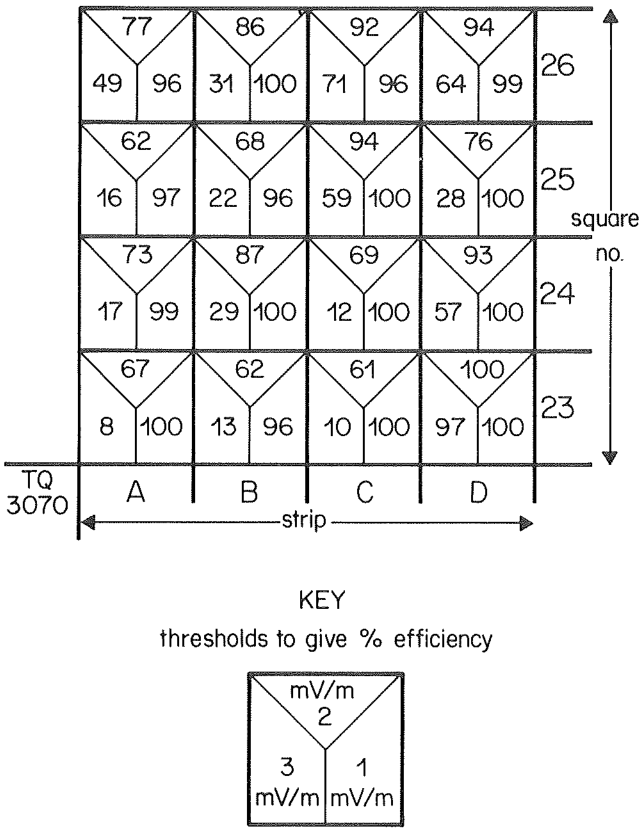

Fig. 14 - Communications efficiency of the Brookmans Park transmitter in central London for various mute levels

Assuming a network with 50 km separating transmitters and a service radius of 30 km, then the maximum overlap would be 10 km. Using 600 kHz field strength/distance information for average conductivity,[3] the implication is that for a motorist to stay just within range when travelling between transmitters, the receiver should retain its overall sensitivity to better than 2 dB. Moreover, any increase in sensitivity should be similarly limited, otherwise overlaps would become unduly excessive. So long as such a specification is accepted, together with the requirement for any production receivers to be marketed with a combined aerial package, then the work contained herein forms the basis of a workable information service. Nevertheless, to obtain maximum versatility of coverage it is necessary to fit a two-level mute switch, giving say 3 mV/m and 1 mV/m. If the switch is driver operated, it would have to be suitably marked to describe the information mode as either applicable to 'Town/Country' or 'Local/Local plus adjoining areas'.

While the use of open and close signals represents a valuable aid to the performance of the system, there is a case for some further development in the method used in the receiver to operate the muting. An improved method of muting control, known as the ring system, has in fact been developed since the completion of the field work described here; details of this system are included in a further report in course of preparation.

8. Acknowledgements

The author would like to thank colleagues in Chief Engineer Transmitters Department for their assistance in providing and maintaining the specially required transmitting equipment at Brookmans Park and Tatsfield. Also, the constructive advice on car radio design and tone decoder operation given by Mr. J.W.A. Hooper of Philips Electrical Limited and Mr. J. Woodgate of ITT, is gratefully acknowledged.

9. References

1. SANDELL, R.S. *and* HARMAN, M.W. 1975. A traffic information service employing time division multiplex transmission. BBC Research Department Report No. 1975/9. (See also BBC Engineering, 1975, No. 100, p.3.)

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10. Appendix

10.1. Transmitter control and modulation equipment

Fig. 15 shows the complete tape format with an active transmitter period of 30 seconds on both channel 1 and 2. The minimum time between operations is two seconds. Each track was recorded with three different types of information:

(i) A 6 kHz sine wave, which when present, operated the 'carrier on' switch at the appropriate transmitter. When the 6 kHz ceased, the associated trailing edge from each track was used to determine the required delay between consecutive north and south transmissions.

(ii) A 2325 Hz tone, frequency-modulated by a 115 Hz square wave. This corresponded to the radiated subcarrier forming the opening and closing signals. The pre-message opening signal had a duration of one second and a frequency deviation of ±175 Hz while the closing signal for restoring the mute condition had a duration of half a second and ±75 Hz deviation.

(iii) A test message to simulate traffic announcements. The transmitter and receiver switching codes were the same on both tape channels, and for ease of station identification, a male and female voice was used to modulate the North London and South London stations respectively.

The various control and modulation stages following the tape player are shown as a block diagram in Fig. 16. By filtering, rectifying, then differentiating the mixed 6 kHz output from both tape player channels, it was possible to derive a positive and negative pulse at the start and finish of each transmission. The positive pulse was then removed to leave a negative timer trigger just at the end of every announcement. Once triggered, the timer immediately disconnected the supply to the tape player and prevented the capstan motor running until a selected duration had expired, whereupon the machine would re-start. The control to preset the timer was brought out to the front panel of the unit and gave a range of 0 to 80 seconds. A switch was available to override the 'auto-delay' system and give a rapid series of announcements to aid traffic receiver alignment. To provide programme feed and control signals for the Brookmans Park transmitting station, channel 1 of

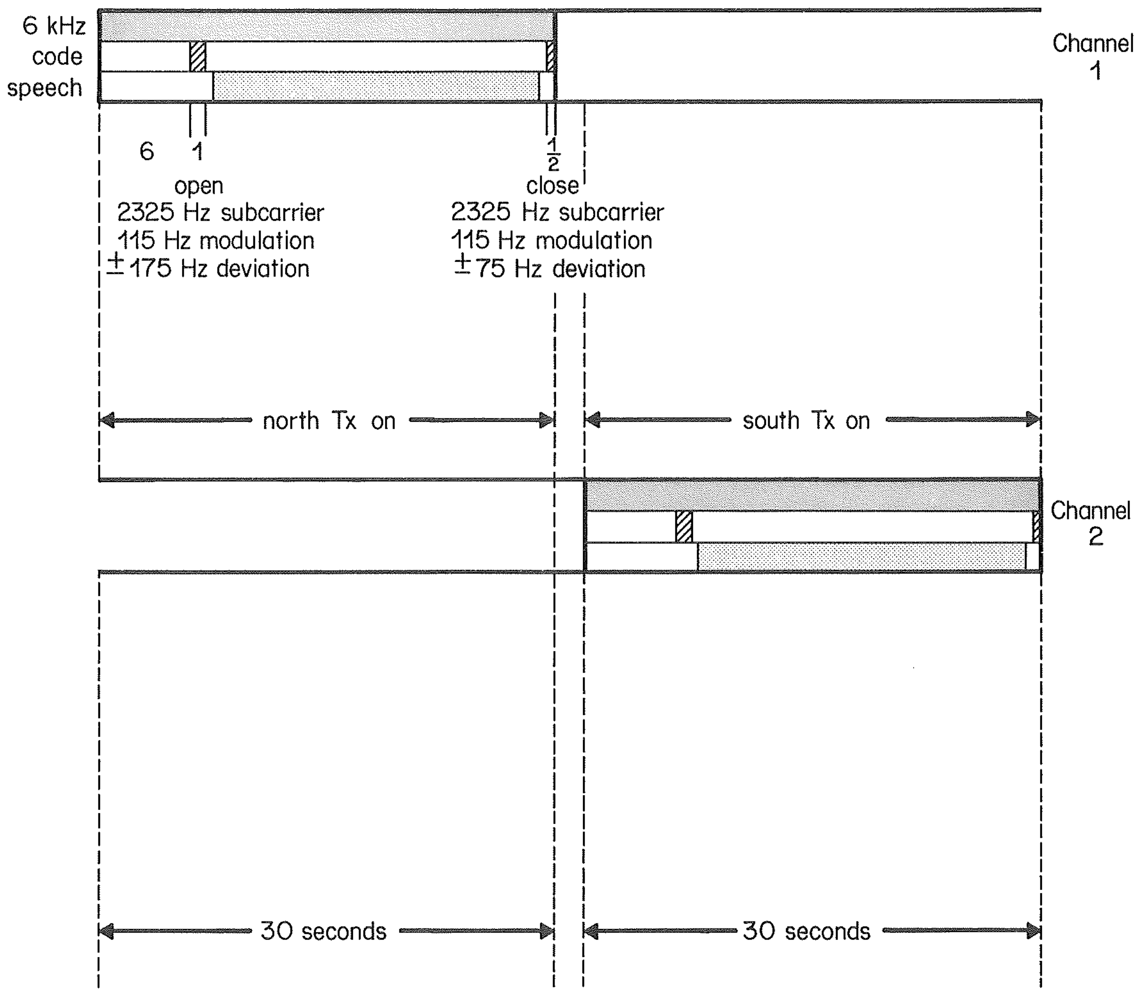

Fig. 15 - Tape format

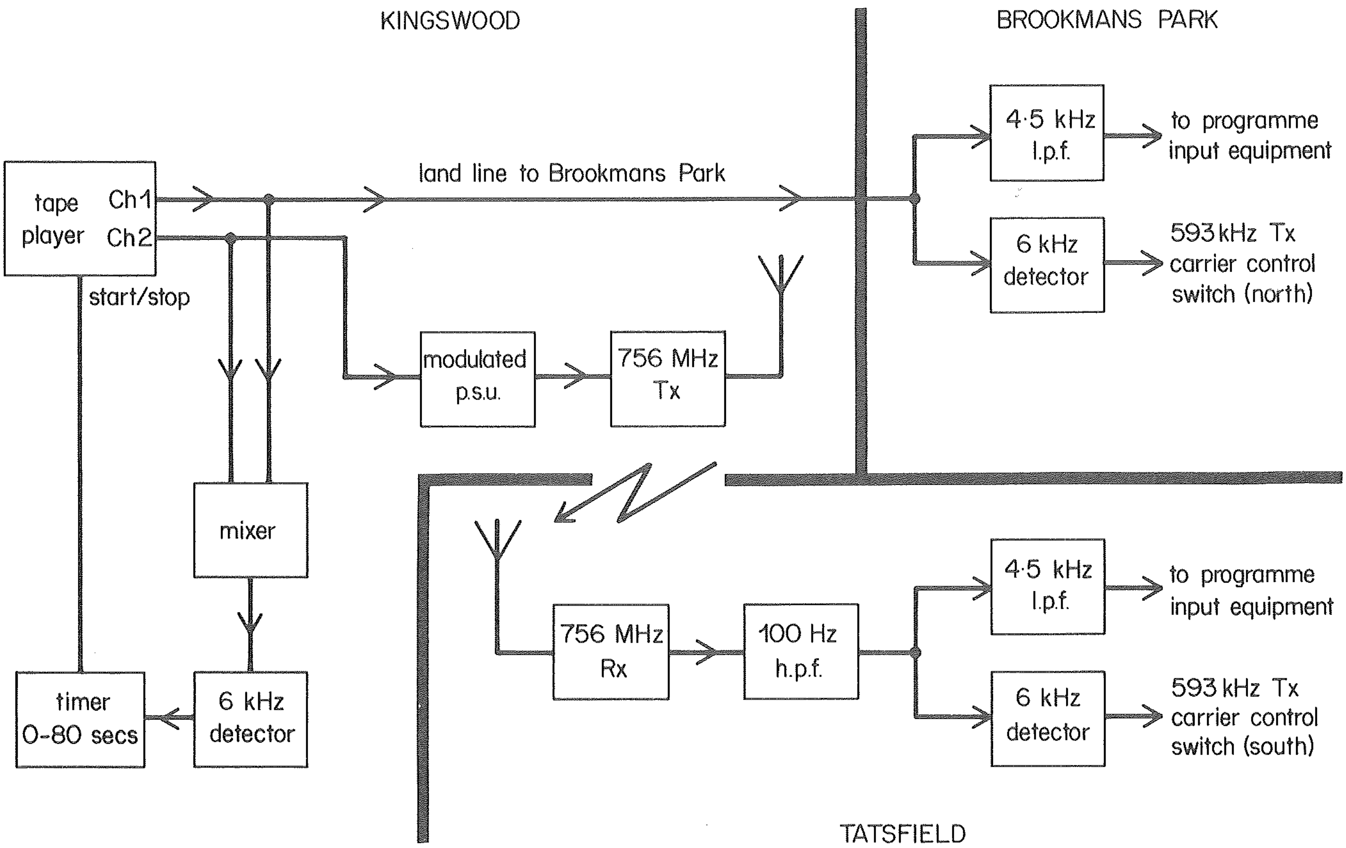

Fig. 16 - Traffic information transmitter control

the tape player output was fed to a 600Ω inter-connecting line via a distribution amplifier.

The sending levels to line were:—

6 kHz transmitter control	—8 dB relative to zero level (PPM2)
2325 Hz receiver code	—4 dB relative to zero level (PPM3)
Speech peaks	+8 dB relative to zero level (PPM6)

Lines to Tatsfield were not readily available, so the output from channel 2 was used to frequency modulate a 756 MHz u.h.f. link. The level of audio to the link modulator was made adjustable by employing a second variable gain distribution amplifier which was set to give a deviation not exceeding ±15 kHz to accord with the narrow band receiver employed. It was not until the u.h.f. link to Tatsfield had been demodulated and amplified, that it was possible to establish the above levels for driving programme input equipment similar to that used at Brookmans Park. Apart from a 100 Hz high-pass filter to remove some low-frequency jitter on the phase modulator, both stations had the same base-band control network. The block diagram shows two more units at each station; a tuned detector that switched on the mains input to the transmitter HT supply while the 6 kHz was present, and a 4·5 kHz low-pass filter to prevent 6 kHz modulation of the 593 kHz carrier.

10.2. System demonstrations using a prototype receiver design

10.2.1. Demonstration equipment

In order to demonstrate reception could be limited to just the motorist's local traffic information transmitter, a fixed tuned receiver was developed* that would respond in accordance with the specification and switching signals mentioned in 2.3 and 10.1 (ii). Furthermore, it was a simple matter to arrange for the bi-stable circuit in the traffic receiver decoder to automatically disconnect the input to the audio amplifier on a stop code and reconnect on a start code. Hence, in the absence of motoring information the loudspeaker channel could be made available for other purposes and a choice between various alternative 'in car' entertainment sources could readily be switched through, either from a standard MF/LF/VHF tuner or a cassette machine. To allow for a common receiving aerial, the problem of an r.f. feed to the main car radio was overcome by building a splitter into the first stage of the traffic

* The design of the traffic receiver can largely be attributed to P.L. Marsden, who together with D.M. Hodge and G.B. Richardson, contributed substantially to the whole field trial.

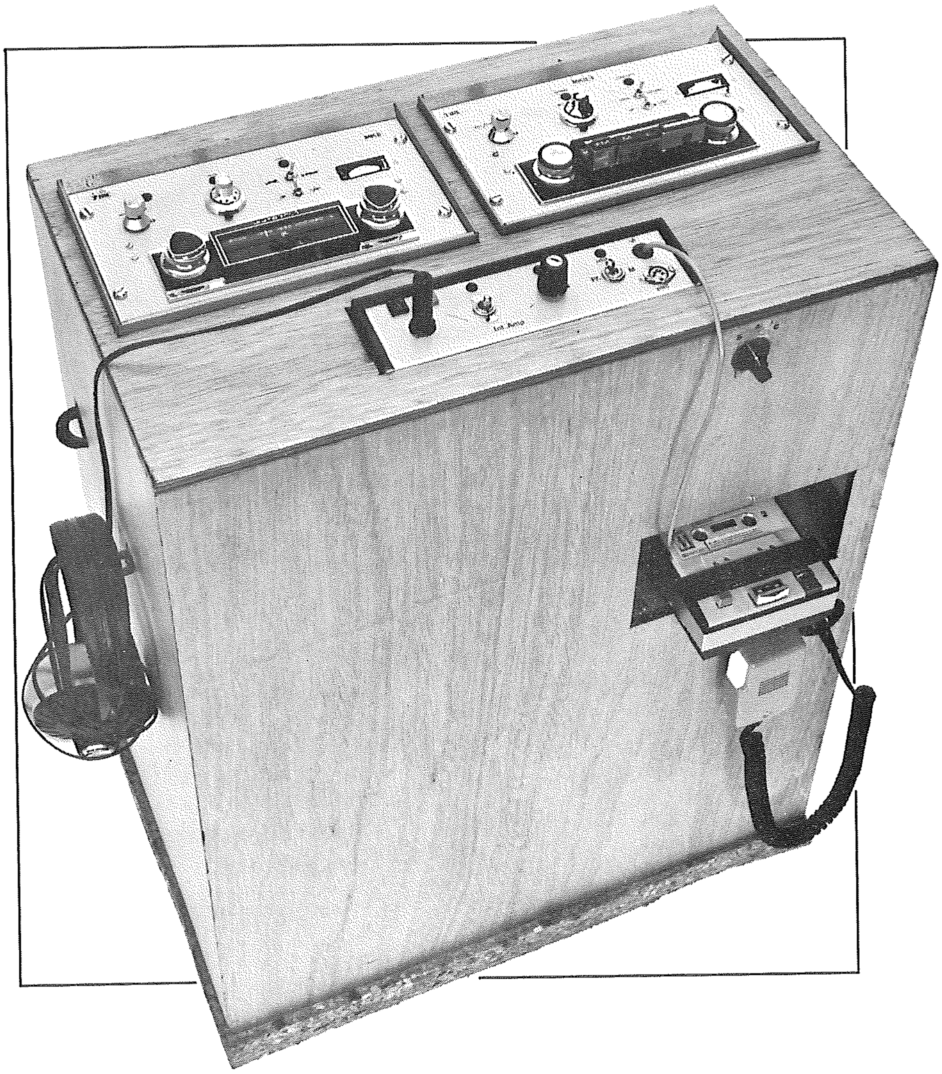

Fig. 17 - Demonstration console

receiver and providing a broadband outlet. This led to the construction of the all purpose unit pictured in Fig. 17 with which it was possible to listen to test messages radiated from transmitters in time-division multiplex while travelling in a vehicle. The unit contained two complete sets of combined standard car radio and prototype traffic information equipments positioned in the upper left and right of the console top panel. From what has gone before, the block diagram of a combined car radio and traffic information facility, Fig. 18, is self evident, apart from explaining the purpose of the timer which was introduced to re-set the muting if a closing code was missed due to bridges, tunnels, etc. Each receiver output was connected to a mixer/amplifier which also included a three channel pre-listen facility to monitor either radio programmes or the tape cassette player. It was therefore possible to make a continuous presentation of any demonstration and where necessary, address the audience using a built-in microphone circuit. A v.h.f. intercom was also mounted inside the console to provide an engineering link to Brookmans Park, Tatsfield and Kingswood so that the demonstration party could be kept informed about any technical problems with the transmitter network.

10.2.2. Demonstration modes

The experiment was demonstrated on about ten separate occasions to various interested parties, including EBU Sub-group K4, members of BBC staff, representatives from the Transport & Road Research Laboratory, Police, Department of the Environment, Home Office, Radio Industry and the technical press. Depending on the number of people attending, the equipment was installed in either a saloon car, mini-bus or 49 seater coach and always gave satisfactory results using commercially manufactured whip aerials, regardless of the type of vehicle. Routes tended to be in accordance with circumstance, but in the main included an area extending from Kingswood Warren, North to Harrow and from Purley, West to Maidenhead. The modes of operation presented were always basically the same, but the running order would change for different starting and finishing points. For demonstration purposes, the optimum subjective benefit was obtained when the two transmitters were each switched on every two minutes, with the 30 second test message alternating between each station every single minute. A typical journey was simulated as follows:

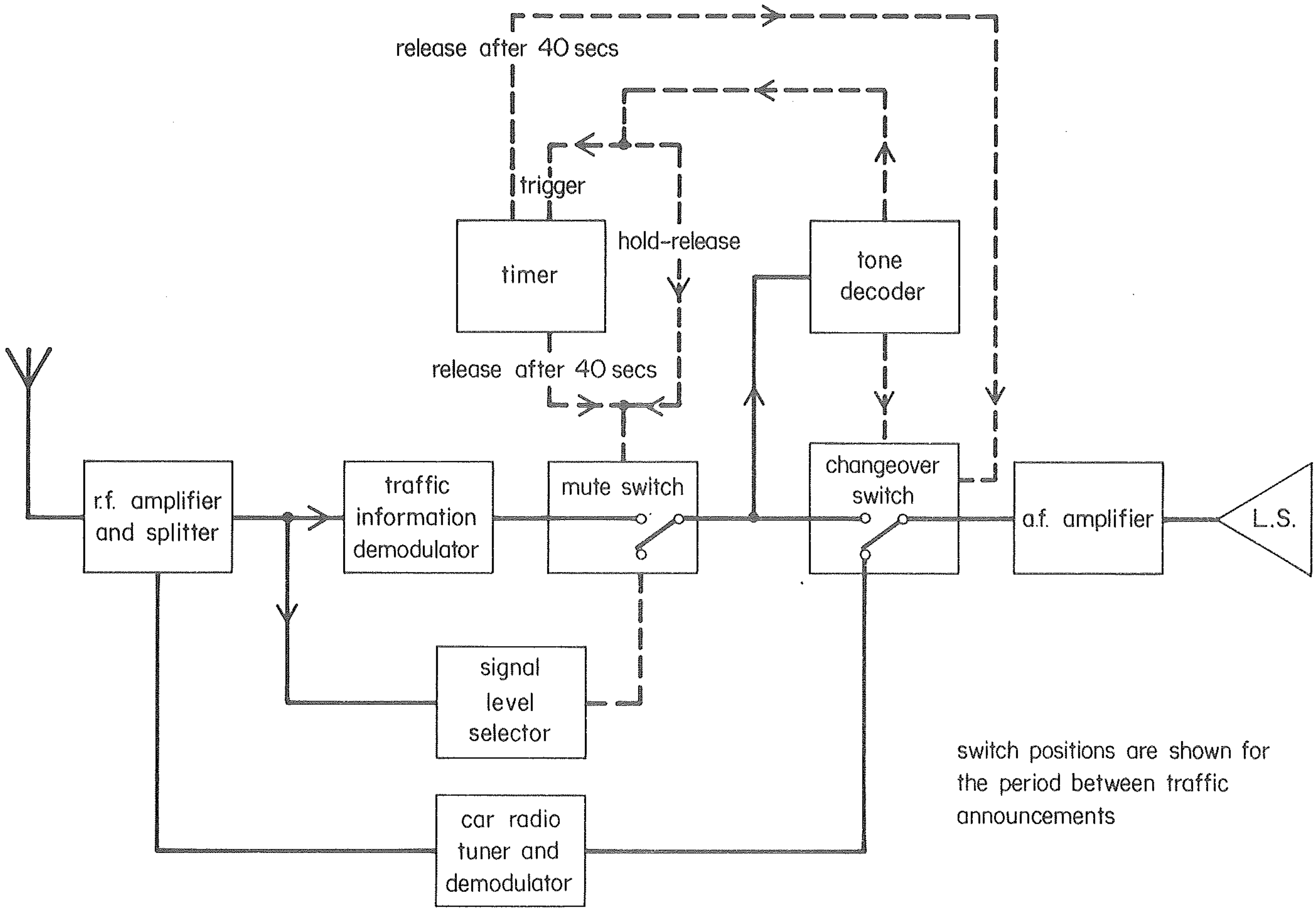

Fig. 18 - Combined car radio and traffic information facility

Signal circuits — Switching circuits

Mode (i): Leave central London heading West, with traffic receiver mute switched to 'Town'. Maximum traffic information obtained because vehicle was travelling through a coverage overlap with fields greater than 1 mV/m in urban areas from both stations. All available transmissions from both Brookmans Park and Tatsfield received. Radio and cassette machine turned off giving silence between announcements.

Mode (ii): Out of town and starting to head North. As items of main interest would come from the more local Brookmans Park transmitter, reject Tatsfield by switching mute to 'Country'. Silence between announcements retained.

Mode (iii): Continue listening to Brookmans Park only, but turn on the car radio tuned to a programme of the travellers choice, say Radio 2, which is then automatically interrupted by relevant local traffic information.

Mode (iv): Turn East and continue with Brookmans Park only, but none of the radio programmes to listeners liking. Select switching between local traffic information and a music cassette.

Mode (v): Turn off cassette player for better concentration while joining a busy south-bound trunk road, leaving Brookmans Park only, to provide local traffic information.

Mode (vi): Although approaching the centre of London the road-side remains open and so appertains a rural condition giving reliable reception of just Brookmans Park with the mute switched to 'Country'. By switching the receiver to 'Town', the lower mute sensitivity permits decoding of both the local plus any adjacent stations which in this case added just Tatsfield. To complete the programme, demonstrate this option and obtain additional information about traffic conditions South of London. Such reports could influence the route selected even while entering North London, if for instance, the destination was Brighton.

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